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Gokhale

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(54) **SYSTEMS AND METHODS FOR AN ENGINE**

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See application file for complete search history.

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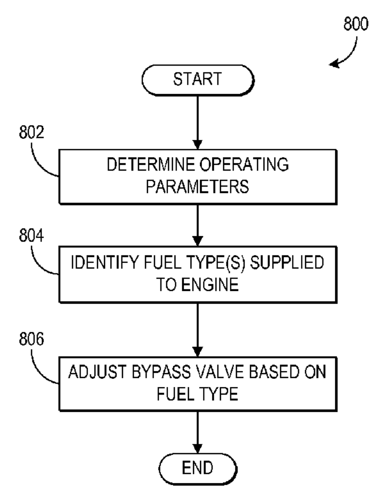
(57) **ABSTRACT**

Methods and systems for an engine are provided. In one example, a system for an engine comprises an exhaust passage through which exhaust gas is configured to flow from the engine, a turbocharger with a turbine positioned in the exhaust passage, an exhaust gas treatment system disposed in the exhaust passage upstream of the turbine and including at least one exhaust gas treatment device and a bypass with a bypass valve, the bypass valve configured to be adjusted to reduce exhaust gas flow through the exhaust gas treatment system in response to a transient engine operating condition, and an exhaust gas recirculation system coupled between the exhaust passage and an intake passage of the engine, the exhaust gas recirculation system including an exhaust gas recirculation passage and at least one exhaust gas recirculation valve, an inlet of the exhaust gas recirculation system positioned upstream of the exhaust gas treatment system.

23 Claims, 7 Drawing Sheets



(51) **Int. Cl.**

B61C 5/04	(2006.01)
F01N 3/20	(2006.01)
F02D 41/02	(2006.01)
F01N 3/021	(2006.01)
F02B 37/00	(2006.01)
F02B 37/013	(2006.01)
F02B 37/12	(2006.01)
F02B 37/20	(2006.01)
F02B 39/16	(2006.01)
F02D 41/00	(2006.01)
F01N 9/00	(2006.01)
F01N 13/00	(2010.01)
F02D 19/06	(2006.01)
F02M 25/07	(2006.01)
F02D 13/02	(2006.01)

(52) **U.S. Cl.**

CPC ***F01N 3/103*** (2013.01); ***F01N 3/2053*** (2013.01); ***F01N 9/00*** (2013.01); ***F01N 13/0097*** (2014.06); ***F02B 37/00*** (2013.01); ***F02B 37/013*** (2013.01); ***F02B 37/12*** (2013.01); ***F02B 37/20*** (2013.01); ***F02B 39/16*** (2013.01); ***F02D 19/0647*** (2013.01); ***F02D 41/0007*** (2013.01); ***F02D 41/0025*** (2013.01); ***F02D 41/0055*** (2013.01); ***F02D 41/0235*** (2013.01); ***F02D 41/10*** (2013.01); *F01N 2410/00* (2013.01); *F01N 2410/10* (2013.01); *F01N 2900/08* (2013.01); *F02D 13/0269* (2013.01); *F02D 19/0692* (2013.01); *F02D 2041/0265* (2013.01); *F02D 2200/0414* (2013.01); *F02D 2200/0802* (2013.01); *F02D 2200/602* (2013.01); *Y02T 10/142* (2013.01); *Y02T 10/144* (2013.01); *Y02T 10/20* (2013.01); *Y02T 10/47* (2013.01)

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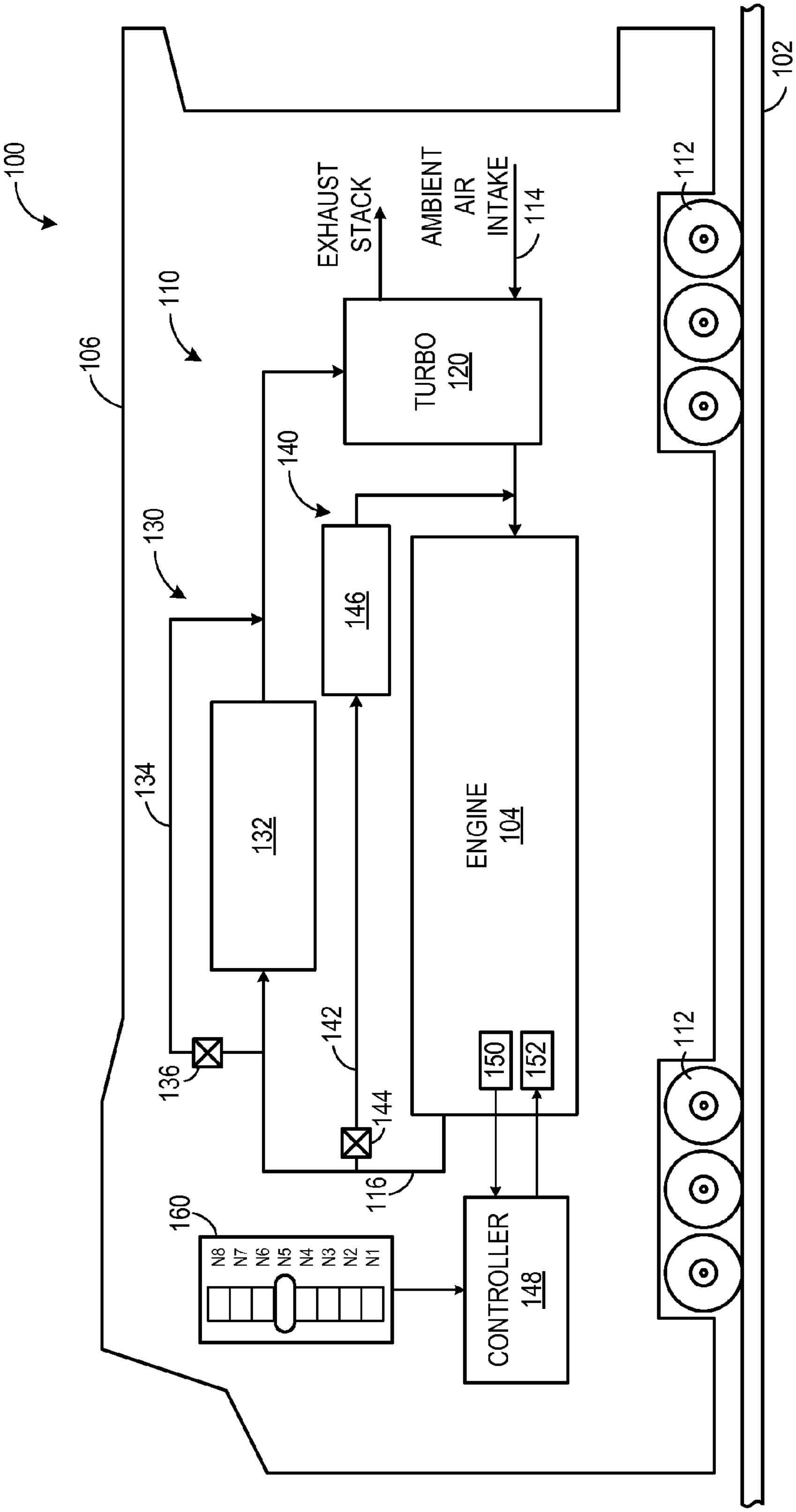

100
106
110
EXHAUST STACK
AMBIENT AIR INTAKE
114
112
102
TURBO 120
140
130
146
134
132
ENGINE 104
142
136
144
150
152
116
160
N8 N7 N6 N5 N4 N3 N2 N1
CONTROLLER 148

FIG. 1

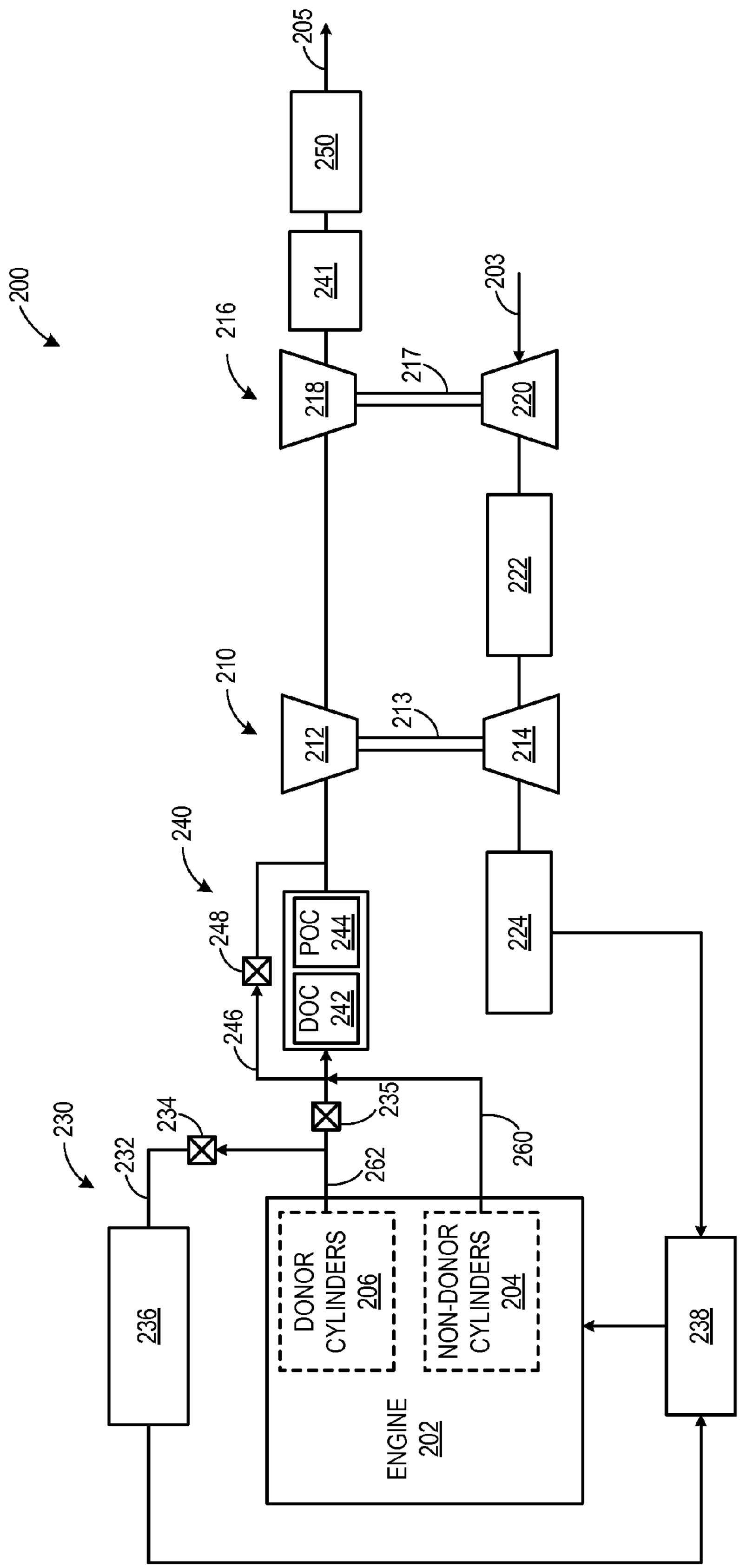

205
250
241
200
216
218
217
203
220
222
210
212
213
214
240
248
POC
244
DOC
242
246
235
234
230
232
262
260
224
DONOR
CYLINDERS
206
NON-DONOR
CYLINDERS
204
236
238
ENGINE
202

FIG. 2

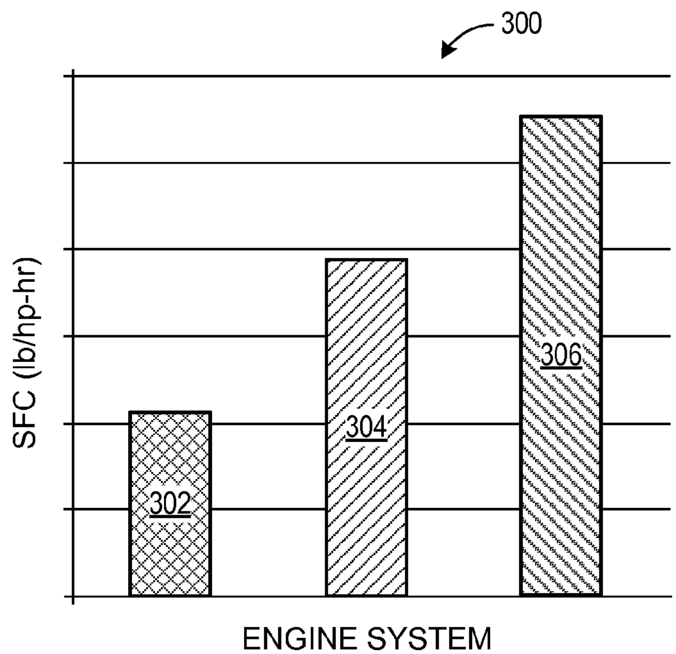

300
SFC (lb/hp-hr)
302
304
306
ENGINE SYSTEM

FIG. 3

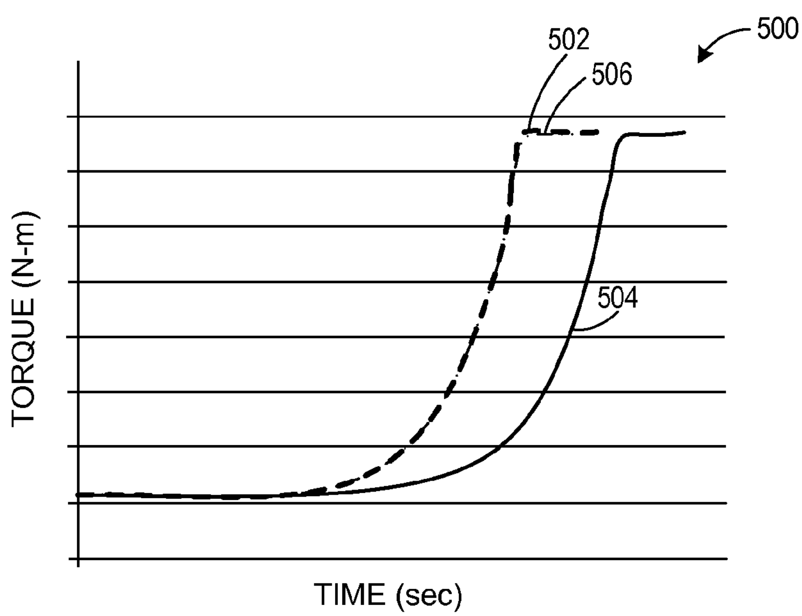

500
502
506
504
TORQUE (N-m)
TIME (sec)

FIG. 5

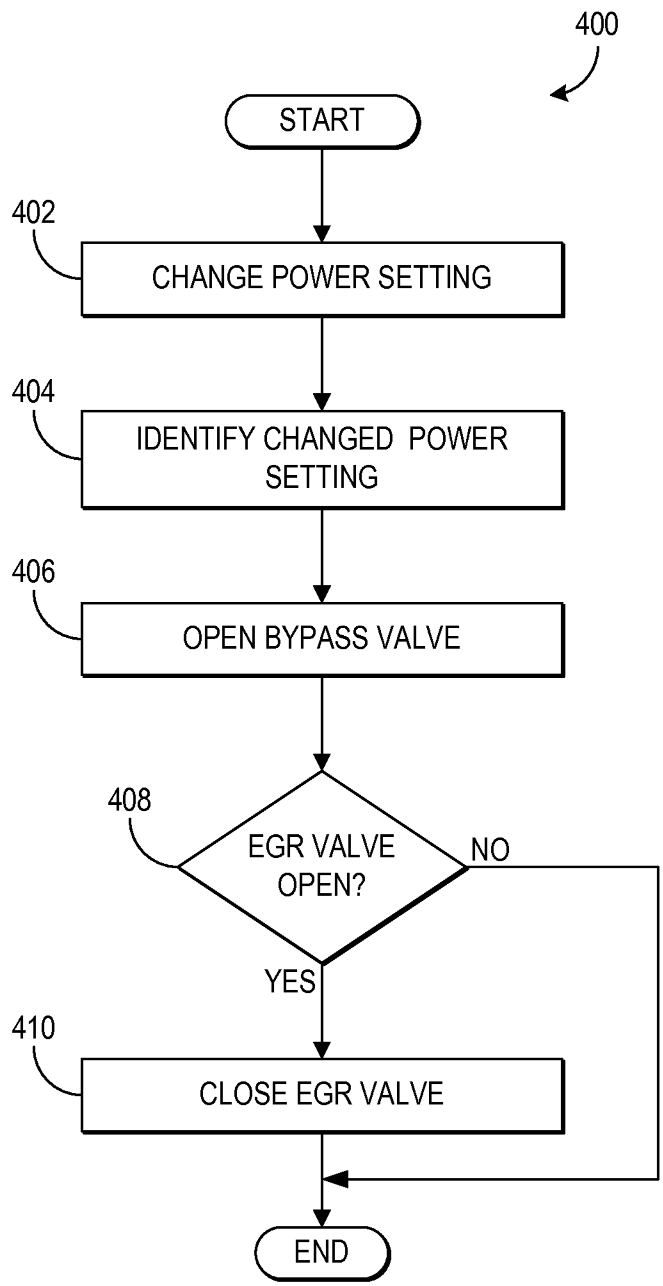

400
START
402
CHANGE POWER SETTING
404
IDENTIFY CHANGED POWER SETTING
406
OPEN BYPASS VALVE
408
EGR VALVE OPEN?
NO
YES
410
CLOSE EGR VALVE
END

FIG. 4

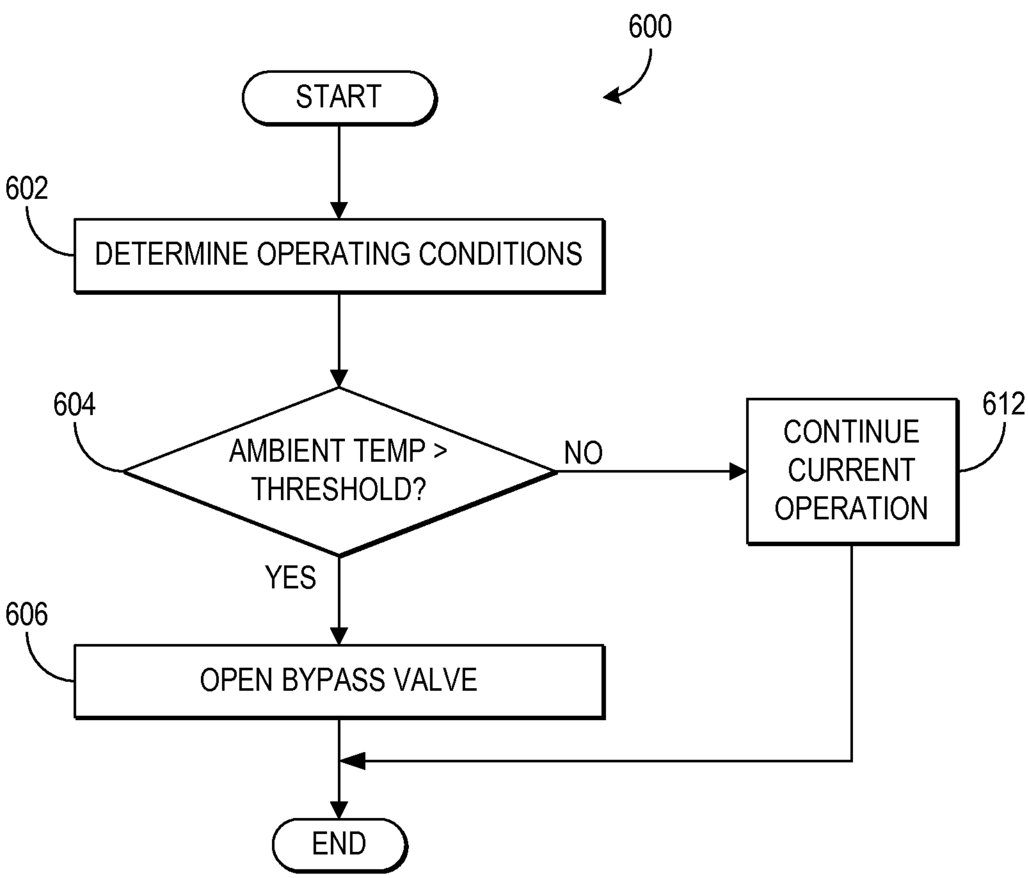
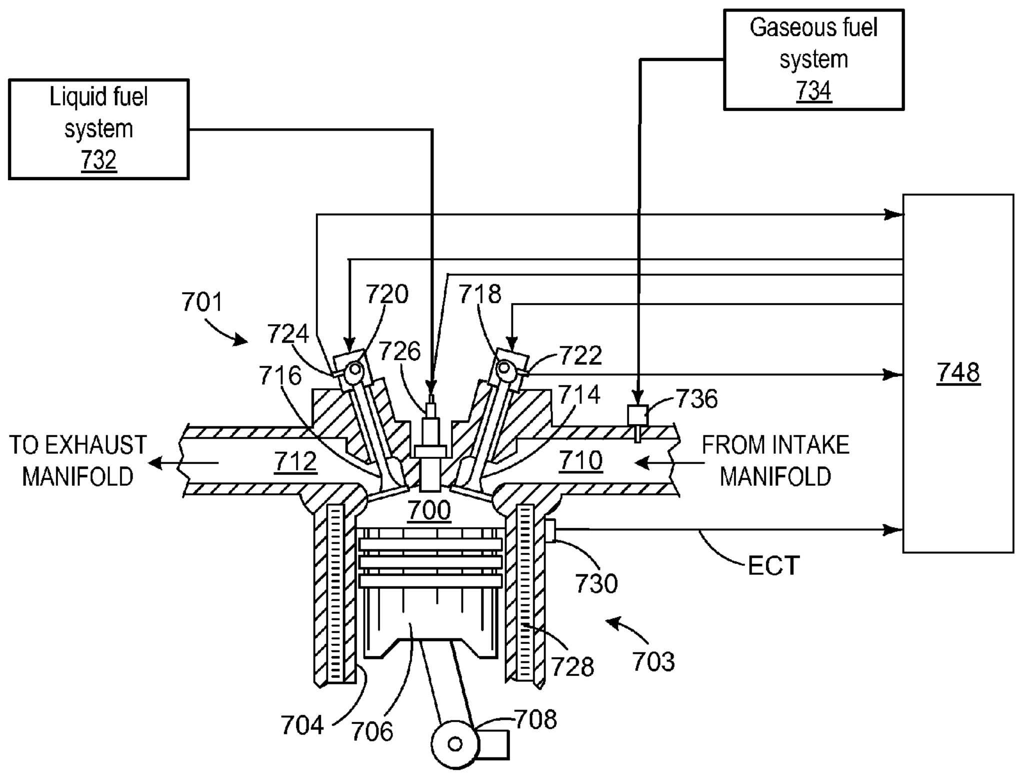

600
START
602
DETERMINE OPERATING CONDITIONS
604
AMBIENT TEMP > THRESHOLD?
NO
612
CONTINUE CURRENT OPERATION
YES
606
OPEN BYPASS VALVE
END

FIG. 6



Liquid fuel system 732
Gaseous fuel system 734
748
701
724
720
726
718
722
716
714
736
TO EXHAUST MANIFOLD
712
710
FROM INTAKE MANIFOLD
700
ECT
730
703
728
704
706
708

FIG. 7

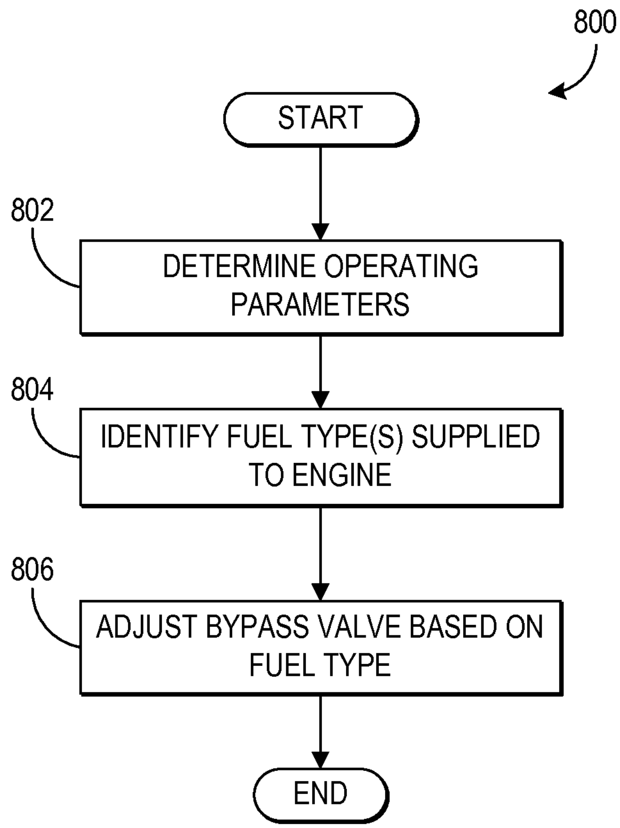

800
START
802
DETERMINE OPERATING PARAMETERS
804
IDENTIFY FUEL TYPE(S) SUPPLIED TO ENGINE
806
ADJUST BYPASS VALVE BASED ON FUEL TYPE
END

FIG. 8

SYSTEMS AND METHODS FOR AN ENGINE

RELATED APPLICATIONS

This application is a continuation-in-part from U.S. patent application Ser. No. 13/152,361, entitled SYSTEMS AND METHODS FOR AN ENGINE, filed Jun. 3, 2011, which is hereby incorporated in its entirety herein by reference for all purposes.

FIELD

Embodiments of the subject matter disclosed herein relate to systems and methods for an engine with an exhaust gas treatment device.

BACKGROUND

During operation, internal combustion engines generate various combustion by-products that are emitted from the engine in an exhaust stream. As such, various approaches may be utilized in order to reduce regulated emissions. In some examples, nitrogen oxide (NO_x) emissions may be reduced by employing exhaust gas recirculation (EGR), carrying out combustion in the engine with a Miller cycle, and/or including an exhaust gas treatment system with a device such as a NO_x trap in an exhaust passage of the engine.

In other examples, the inventors herein have recognized the exhaust gas treatment system may include devices such as a diesel oxidation catalyst (DOC) and a particulate oxidation catalyst (POC) to reduce particulate matter emissions. However, when the exhaust gas treatment system including the DOC and POC is positioned downstream of a turbocharger, specific fuel consumption may be increased resulting in decreased fuel efficiency. On the other hand, when the exhaust gas treatment system including the DOC and POC is positioned upstream of a turbocharger, a transient response time of the engine may be increased during engine loading, as a portion of exhaust thermal energy is absorbed by the exhaust gas treatment system before the exhaust gas flow reaches the turbocharger.

BRIEF DESCRIPTION

In one embodiment, a system for an engine comprises an exhaust passage through which exhaust gas is configured to flow from the engine, a turbocharger with a turbine positioned in the exhaust passage, an exhaust gas treatment system disposed in the exhaust passage upstream of the turbine, the exhaust gas treatment system including at least one exhaust gas treatment device and a bypass with a bypass valve, the bypass valve configured to be adjusted to reduce exhaust gas flow through the exhaust gas treatment system in response to a transient engine operating condition, and an exhaust gas recirculation system coupled between the exhaust passage and an intake passage of the engine, the exhaust gas recirculation system including an exhaust gas recirculation passage and at least one exhaust gas recirculation valve, an inlet of the exhaust gas recirculation system positioned upstream of the exhaust gas treatment system.

By including a valved bypass around the exhaust gas treatment device, exhaust gas flow through the exhaust gas treatment device may be reduced during transient conditions by opening the valve. As such, the exhaust gas flow may bypass the exhaust gas treatment device resulting in a decrease of thermal energy absorbed by the exhaust gas treatment device, and an increase of thermal energy available for the turbocharger. In this manner, the turbocharger may produce a greater amount of boost, which may result in a decrease in transient response time. Further, because the exhaust gas treatment device is positioned upstream of the turbocharger, specific fuel consumption may be maintained.

It should be understood that the brief description above is provided to introduce in simplified form a selection of concepts that are further described in the detailed description. It is not meant to identify key or essential features of the claimed subject matter, the scope of which is defined uniquely by the claims that follow the detailed description. Furthermore, the claimed subject matter is not limited to implementations that solve any disadvantages noted above or in any part of this disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be better understood from reading the following description of non-limiting embodiments, with reference to the attached drawings, wherein below:

FIG. **1** shows an example embodiment of a rail vehicle with an exhaust gas treatment system with a valved bypass according to an embodiment of the invention.

FIG. **2** shows an example embodiment of an engine system with an exhaust gas treatment system with a valved bypass.

FIG. **3** shows a graph illustrating specific fuel consumption with respect to position of an exhaust gas treatment system.

FIG. **4** shows a flow chart illustrating a method for an engine system with an exhaust gas treatment system with a valved bypass.

FIG. **5** shows a graph illustrating example torque curves for various engine systems.

FIG. **6** shows a flow chart illustrating a method for an engine system with an exhaust gas treatment system with a valved bypass.

FIG. **7** shows a single cylinder of a multi-cylinder engine configured to operate with one or more types of fuel.

FIG. **8** shows a flow chart illustrating a method for an engine system with an exhaust gas treatment system with a valved bypass.

DETAILED DESCRIPTION

The following description relates to various embodiments of methods and systems for controlling emissions from an engine. In one example embodiment, a system for an engine includes an exhaust passage through which exhaust gas flows from the engine, a turbocharger with a turbine positioned in the exhaust passage, and an exhaust gas treatment system disposed in the exhaust passage upstream of the turbocharger, the exhaust gas treatment system including a diesel oxidation catalyst and a particulate oxidation catalyst and a bypass with a bypass valve. The system further includes a controller configured to identify or detect a transient engine operating condition and, in response to the transient engine operating condition, adjust the bypass valve to reduce exhaust flow through the exhaust gas treatment system. In one example, exhaust gas flow through the exhaust gas treatment device may be reduced during transient conditions by opening the valve. Thus, the exhaust gas flow may bypass the exhaust gas treatment device resulting in a decrease of thermal energy absorbed by the exhaust gas treatment device, and an increase of thermal energy available for the turbocharger. In this manner, the turbocharger may produce a greater amount of boost, which may result in a decrease in transient response. Further, by opening the valve during transient conditions, particulate matter loading in the exhaust gas treatment device may be substantially reduced during transient conditions.

The approach described herein may be employed in a variety of engine types, and a variety of engine-driven systems. Some of these systems may be stationary, while others may be on semi-mobile or mobile platforms. Semi-mobile platforms may be relocated between operational periods, such as mounted on flatbed trailers. Mobile platforms include self-propelled vehicles. Such vehicles can include mining equipment, marine vessels, on-road transportation vehicles, off-highway vehicles (OHV), and rail vehicles. For clarity of illustration, a locomotive is provided as an example mobile platform supporting a system incorporating an embodiment of the invention.

Before further discussion of the exhaust gas treatment system bypass approach, an example of a vehicle system connected to a platform is disclosed in which the exhaust gas treatment system may be configured for an engine in a vehicle, such as a rail vehicle. For example, FIG. **1** shows a block diagram of an example embodiment of a vehicle system **100** (e.g., a locomotive system), herein depicted as a rail vehicle **106**, configured to run on a rail **102** via a plurality of wheels **112** connected to the platform. As depicted, the rail vehicle **106** includes an engine system **110** with an engine **104**, such an internal combustion engine. In other non-limiting embodiments, the engine **104** may be a stationary engine, such as in a power-plant application, or an engine in a marine vessel or OHV propulsion system.

The engine **104** receives intake air for combustion from an intake passage **114**. The intake passage **114** receives ambient air from an air filter (not shown) that filters air from outside of the rail vehicle **106**. Exhaust gas resulting from combustion in the engine **104** is supplied to an exhaust passage **116**. Exhaust gas flows through the exhaust passage **116**, and out of an exhaust stack of the rail vehicle **106**. In one example, the engine **104** is a diesel engine that combusts air and diesel fuel through compression ignition. In other non-limiting embodiments, the engine **104** may combust fuel including gasoline, kerosene, biodiesel, or other petroleum distillates of similar density through compression ignition (and/or spark ignition). The engine **104** may be a V-6, V-8, V-10, V-12, V-16, I-4, I-6, I-8, opposed 4, or another engine type.

The engine system **110** includes a turbocharger **120** that is arranged between the intake passage **114** and the exhaust passage **116**. The turbocharger **120** increases air charge of ambient air drawn into the intake passage **114** in order to provide greater charge density during combustion to increase power output and/or engine-operating efficiency. The turbocharger **120** may include a compressor (not shown in FIG. **1**) which is at least partially driven by a turbine (not shown in FIG. **1**). While in this case a single turbocharger is included, the system may include multiple turbine and/or compressor stages, such as the engine system **200** depicted in FIG. **2** which includes a two-stage turbocharger. Further, in some embodiments, a wastegate (not shown) may be provided which allows exhaust gas to bypass the turbocharger **120**. The wastegate may be opened, for example, to divert the exhaust gas flow away from the turbine. In this manner, the rotating speed of the compressor, and thus the boost provided by the turbocharger **120** to the engine **104** may be regulated during steady state conditions.

The engine system **110** further includes an exhaust gas treatment system **130** disposed in the exhaust passage upstream of the turbine of the turbocharger **120**. As will be described in greater detail below, the exhaust gas treatment system **130** may include one or more components. In one example embodiment, the exhaust gas treatment device **132** may include a diesel oxidation catalyst (DOC) and a particulate oxidation catalyst (POC), where the DOC is positioned upstream of the POC in the exhaust gas treatment system. In other embodiments, the exhaust gas treatment device **132** may additionally or alternatively include a diesel particulate filter, a selective catalytic reduction (SCR) catalyst, three-way catalyst, NO_x trap, various other emission control devices or combinations thereof. Further, in some embodiments, one or more additional exhaust gas treatment devices may be positioned downstream of the turbocharger.

As depicted in FIG. **1**, the exhaust gas treatment system **130** further includes a bypass **134** with a bypass valve **136**. The bypass valve **136** may be controlled to adjust the flow of exhaust gas around the exhaust gas treatment device **132**. The bypass valve **136** may be any element that can be controlled to selectively partially or completely block a passage. As an example, the bypass valve may be a gate valve, a butterfly valve, a globe valve, an adjustable flap, or the like. In one example, the bypass valve **136** is configured to be adjusted to reduce exhaust gas flow through the exhaust gas treatment system in response to a transient engine operating condition. For example, in one embodiment, the system includes a control unit that is configured to adjust the bypass valve **136** (e.g., by generating control signals to which the valve is responsive) to reduce exhaust gas flow through the exhaust gas treatment system in response to the transient engine operating condition. In another embodiment, the bypass valve **136** is configured to self-actuate to an at least partially open position during the transient operating condition, for reducing the exhaust gas flow through the exhaust gas treatment system. (For this purpose, in such an embodiment, the valve could include a temperature-dependent actuation mechanism, such as a bi-metal member, that is responsive to a temperature associated with the transient operating condition.) In one example, the bypass valve **136** may be opened such that exhaust gas flow through the exhaust treatment device is substantially reduced during transient engine operating conditions. In another example, the bypass valve may be opened such that exhaust gas flow through the exhaust gas treatment device is substantially reduced in order to cool the exhaust gas treatment device under extreme ambient conditions (e.g., during tunneling operation in which the vehicle is travelling through a tunnel).

The engine system **110** further includes an exhaust gas recirculation (EGR) system **140**, which routes exhaust gas from the exhaust passage **116** upstream of the exhaust gas treatment device **132** to the intake passage downstream of the turbocharger **120**. Thus, an EGR inlet is located upstream of the exhaust gas treatment device **132**. The EGR system **140** includes an EGR passage **142** and an EGR valve **144** operably disposed in the EGR passage **142** for controlling an amount of exhaust gas that is recirculated from the exhaust passage **116** of engine **104** to the intake passage **114** of engine **104**. In an embodiment, the EGR valve **144** is configured to be closed during the transient engine operating condition. For example, in one embodiment, a control unit is configured to generate a control signal for controlling the EGR valve **144** to a closed position during the transient operating condition. In another embodiment, the EGR valve **144** is configured to self-actuate to a closed position during the transient operating condition, such as the valve having a temperature-dependent actuating mechanism (such as a bi-metal member) that is responsive to a temperature associated with the transient operating condition.

By introducing exhaust gas to the engine **104**, the amount of available oxygen for combustion is decreased, thereby reducing the combustion flame temperatures and reducing the formation of nitrogen oxides (e.g., NO_x). The EGR valve **144** may be an on/off valve controlled by the controller **148**, or it may control a variable amount of EGR, for example. It should be understood, the EGR valve **144** may be any element that can be controlled to selectively partially or completely block a passage. As an example, the EGR valve may be a gate valve, a butterfly valve, a globe valve, an adjustable flap, or the like. In some embodiments, as shown in FIG. **1**, the EGR system **140** further includes an EGR cooler **146** to reduce the temperature of the exhaust gas before it enters the intake passage **114**. As shown in the non-limiting example embodiment of FIG. **1**, the EGR system **140** is a high-pressure EGR system. In other embodiments, the engine system **110** may additionally or alternatively include a low-pressure EGR system, routing EGR from downstream of the turbine to upstream of the compressor.

The rail vehicle **106** further includes a controller **148** to control various components related to the vehicle system **100**. In one example, the controller **148** includes a computer control system. The controller **148** further includes computer readable storage media (not shown) including code for enabling on-board monitoring and control of rail vehicle operation. The controller **148**, while overseeing control and management of the vehicle system **100**, may be configured to receive signals from a variety of engine sensors **150**, as further elaborated herein, in order to determine operating parameters and operating conditions, and correspondingly adjust various engine actuators **152** to control operation of the rail vehicle **106**. For example, the controller **148** may receive signals from various engine sensors **150** including, but not limited to, engine speed, engine load, boost pressure, exhaust pressure, ambient pressure, exhaust temperature, notch setting, etc. Correspondingly, the controller **148** may control the vehicle system **100** by sending commands to various components such as traction motors, alternator, cylinder valves, throttle, etc.

In one example, the controller **148** may receive communication from notch sensors coupled to a notched throttle **160** indicating a power level. For example, the notched throttle **160** includes a plurality of notches, and each notch of the notched throttle **160** may correspond to a discrete power level, or power setting, indicating a fixed power and engine speed. The controller **148** may be configured to identify the change in power setting of the engine due to shift of the notched throttle from one notch to another notch, for example. Although eight notch settings are depicted in the example embodiment of FIG. **1**, in other embodiments, the throttle notch may have more than eight notches or less than eight notches, as well as notches for idle and dynamic brake modes. In other embodiments, the throttle may be a continuous/analog throttle. In some embodiments, the notch setting may be selected by an operator of the rail vehicle **106**. In other embodiments, the controller **148** may determine a trip plan (e.g., a trip plan may be generated using trip optimization software, such as Trip Optimizer™ available from General Electric Company) including notch settings based on engine and/or rail vehicle operating conditions and/or the ambient levels of one or more regulated emissions. In another example, the controller **148** may adjust the bypass valve **136** in response to transient engine operating conditions initiated by a shift of the notched throttle from one notch to another notch (e.g., a shift from N4 to N5). In another example, the controller **148** may be configured to selectively at least partially close the EGR valve **144** in response to a change in a power setting of the engine.

In one example embodiment, an engine system comprises a control module configured to receive a first signal relating to a transient engine operating condition and to generate a control signal in response to the first signal. For example, the control module may be hardware and/or software having functionality as indicated. Hardware and/or software refers to one or more electronic components and/or sets of machine readable instructions, stored on a non-transitory medium, that perform or cause to be performed one ore more designated functions. The control module may be a stand alone unit, or a part of a vehicle controller, such as the controller **148**, or other control unit system on the vehicle. The control signal is configured for control of a bypass control element (e.g., a valve or flap) to adjust an amount of exhaust passing through and bypassed around an exhaust treatment system disposed upstream of a turbine of an engine system turbocharger.

In one example, the control module is configured to generate the control signal as configured to control the bypass control element to a closed position when the first signal is indicative of the transient engine operating condition not present. The control module is further configured to generate the control signal as configured to control the bypass control element to an at least partially open position when the first signal is indicative of the transient engine operating condition being present.

In another example, the exhaust treatment system is configured to be disposed in an exhaust passage upstream of the turbine. The exhaust treatment system comprises at least one exhaust gas treatment device and a bypass for fluidly coupling an end upstream of the at least one exhaust gas treatment device with an end downstream of the at least one exhaust gas treatment device. The exhaust gas treatment system further comprises a bypass control element, wherein the bypass control element is operably coupled with the bypass such that a position of the bypass control element governs an extent to which the bypass is open for passage of fluid.

Thus, in one embodiment, a vehicle system comprises an engine with an exhaust passage through which exhaust gas flows from the engine, a notched throttle including a plurality of notches, each of the notches corresponding to a power setting of the engine, and a turbocharger with a turbine positioned in the exhaust passage. The vehicle system further comprises an exhaust gas treatment system disposed in the exhaust passage upstream of the turbocharger, the exhaust gas treatment system including a diesel oxidation catalyst and a particulate oxidation catalyst and a bypass with a bypass valve, and a controller configured to identify a change in power setting of the engine due to a shift of the notched throttle from one notch to another notch, and in response to the change in power setting, opening the bypass valve to reduce flow through the exhaust gas treatment system.

During transient engine conditions, such as when the notched throttle is shifted from one notch to another notch (e.g., from one power setting to another power setting), the bypass valve of the exhaust gas treatment system may be opened so that the exhaust gas flow from the engine bypasses the exhaust gas treatment device. In this manner, the transient engine response may be improved, as a reduced portion of energy from the hot exhaust gas is not dissipated to the exhaust gas treatment device. Instead, the energy may be utilized by the turbocharger to increase an amount of boost, thereby increasing the pressure of the charge air delivered to the cylinders of the engine such that a time it takes the engine to speed up may be reduced.

Another example embodiment of an engine system **200** is depicted in the schematic diagram shown in FIG. **2**. Similar to the engine system **110** described above with reference to FIG. **1**, the engine system **200** includes an engine **202**, such an internal combustion engine. In other non-limiting embodiments, the engine **202** may be a stationary engine, such as in a power-plant application, or an engine in a marine vessel or off-highway vehicle propulsion system.

The engine **202** receives intake air for combustion from an intake passage **203**. The intake passage **203** receives ambient air from an air filter (not shown) that filters air from outside of the engine system **200**. Exhaust gas resulting from combustion in the engine **202** is supplied to an exhaust passage **205**. In one example, the engine **202** is a diesel engine that combusts air and diesel fuel through compression ignition. In other non-limiting embodiments, the engine **202** may combust fuel including gasoline, kerosene, biodiesel, natural gas, or other petroleum distillates of similar density through compression ignition (and/or spark ignition). Further, in another non-limiting embodiment, the engine may utilize a combustion process such a Miller cycle in order to reduce regulated emissions, such as NO_x, while reducing an impact on specific fuel consumption.

The engine **202** may include any suitable number of cylinders for combustion. For example, the engine **202** may be a V-6, V-8, V-10, V-12, V-16, I-4, I-6, I-8, opposed 4, or another engine type. In some embodiments, one or more of the cylinders of the engine **202** may be donor cylinders that are dedicated to generating exhaust gas for EGR. As depicted in FIG. **2**, the engine **202** may include a plurality of non-donor cylinders **204** that supply exhaust gas exclusively to a non-donor cylinder exhaust manifold **260** and a plurality of donor cylinders **206** that supply exhaust gas exclusively to a donor cylinder exhaust manifold **262**. In one example, the engine is a 12 cylinder engine with six donor cylinders and six non-donor cylinders. In other examples, the engine may include at least one donor cylinder and at least one non-donor cylinder. For example, the engine may have four donor cylinders and eight non-donor cylinders, or three donor cylinders and nine non-donor cylinders. It should be understood, the engine may have any desired numbers of donor cylinders and non-donor cylinders, with the number of donor cylinders typically equal to or lower than the number of non-donor cylinders.

As depicted in FIG. **2**, the non-donor cylinders are coupled to the exhaust passage **205** to route exhaust gas from the engine to atmosphere (after it passes through an exhaust gas treatment system **240** and first and second turbochargers **210** and **216**). The donor cylinders, which provide engine exhaust gas recirculation (EGR), are coupled to an EGR system, explained in more detail below, which routes exhaust gas from the donor cylinders to the intake passage of the engine, and not to atmosphere. By introducing cooled exhaust gas to the engine, the amount of available oxygen for combustion is decreased, thereby reducing combustion flame temperatures and reducing the formation of nitrogen oxides (e.g., NO_x).

The engine system **200** further includes a two-stage turbocharger with a first turbocharger **210** and a second turbocharger **216** arranged in series, each of the turbochargers **210** and **216** arranged between the intake passage **203** and the exhaust passage **205**. The two-stage turbocharger increases air charge of ambient air drawn into the intake passage **203** in order to provide greater charge density during combustion to increase power output and/or engine-operating efficiency. The first turbocharger **210** includes a first turbine **212** which drives a first compressor **214**, the first turbine **212** and the first compressor **214** mechanically coupled via a shaft **213**. The second turbocharger **216** includes a second turbine **218** which drives a second compressor **220**, the second turbine **218** and second compressor **220** mechanically coupled via a shaft **217**. In some embodiments, each of the turbochargers **210** and **216** may be provided with a wastegate (not shown) which allow exhaust gas to bypass the turbocharger **120**. One or both of the wastegates may be opened, for example, to divert the exhaust gas flow away from the turbines. In this manner, the rotating speed of one or both of the compressors, and thus the boost provided by one or both of the turbochargers **210** and **216** to the engine **202** may be regulated during steady state conditions.

As depicted in FIG. **2**, an intercooler **222** is positioned in the intake passage **203** upstream of the first compressor **214** and downstream of the second compressor **220** which cools the intake air compressed by the second compressor **220** before it enters the first compressor **214**. The engine system **200** further includes an aftercooler **224** positioned downstream of the first compressor **214** which cools the intake air compressed by the first compressor **214** before the intake air enters the cylinders of the engine **202**.

The engine system **200** further includes an exhaust gas treatment system **240** disposed upstream of the turbine of the two-stage turbocharger in the exhaust passage. In the example embodiment depicted in FIG. **2**, the exhaust gas treatment system **240** may include a diesel oxidation catalyst (DOC) and a particulate oxidation catalyst (POC), where the DOC is positioned upstream of the POC in the exhaust gas treatment system. By positioning the DOC and POC upstream of the two-stage turbocharger (e.g., in a pre-turbo location), particulate matter (e.g., soot) emission may be reduced while an impact of the exhaust gas treatment device on specific fuel consumption is reduced as compared to a post-turbo location. In other embodiments, the exhaust gas treatment device **132** may additionally or alternatively include a diesel particulate filter, a selective catalytic reduction (SCR) catalyst, three-way catalyst, NO_x trap, various other emission control devices or combinations thereof. Further, in some examples a second exhaust gas treatment system **241**, including one or more exhaust gas treatment devices (e.g., POC, DOC, SCR, LNT, etc.) may be located in the exhaust passage **205** downstream of the turbochargers.

As depicted in FIG. **2**, the exhaust gas treatment system **240** further includes a bypass **246** with a bypass valve **248**. The bypass valve **248** may be controlled to adjust the flow of exhaust gas around the exhaust gas treatment devices **242** and **244**. The bypass valve **248** may be an on/off valve controlled by a controller, or it may control a variable amount of bypass flow. It should be understood, the bypass valve **248** may be any element that can be controlled to selectively partially or completely block a passage. As an example, the bypass valve may be a gate valve, a butterfly valve, a globe valve, an adjustable flap, or the like. As will be described in greater detail below, in one example, the bypass valve **248** may be opened such that exhaust gas flow through the exhaust treatment device is substantially reduced during transient engine operating conditions. In another example, the bypass valve may be opened such that exhaust gas flow through the exhaust gas treatment device is substantially reduced in order to cool the exhaust gas treatment device during tunneling operation, or when a temperature of the exhaust gas treatment devices exceeds a threshold.

The engine system **200** further includes an exhaust gas recirculation (EGR) system **230**, which routes exhaust gas from the exhaust passage **205** upstream of the exhaust gas treatment devices **242** and **244** to the intake passage **203** downstream of the first turbocharger **210**. The EGR system **230** includes an EGR passage **232** and an EGR valve **234** operably disposed in the EGR passage **232** for controlling an amount of exhaust gas that is recirculated from the exhaust passage **205** of engine **202** to the intake passage **203** of engine **104**. In some embodiments, such as the non-limiting embodiment depicted in FIG. **1**, the exhaust gas may be routed to an

EGR mixer **238**, where is it mixed with cooled and compressed intake air before it enters the engine **202**. As described above, by introducing exhaust gas to the engine **202**, the amount of available oxygen for combustion is decreased, thereby reducing the combustion flame temperatures and reducing the formation of nitrogen oxides (e.g., NO_x). The EGR valve **234** may be an on/off valve controlled by a controller, or it may control a variable amount of EGR, for example. It should be understood the EGR valve **234** may be any element that can be controlled to selectively partially or completely block a passage. As an example, the EGR valve may be a gate valve, a butterfly valve, a globe valve, an adjustable flap, or the like. In some embodiments, similar to that as shown in FIG. **1**, the EGR system **230** further includes an EGR cooler **236** to reduce the temperature of the exhaust gas before it enters the EGR mixer **238**. As shown in the non-limiting example embodiment of FIG. **2**, the EGR system **230** is a high-pressure EGR system. In other embodiments, the engine system **200** may additionally or alternatively include a low-pressure EGR system, routing EGR from downstream of the turbine to upstream of the compressor.

In some examples, the donor cylinders may be configured to selectively route exhaust to the intake or to the exhaust passage. For example, the EGR valve **234** may be a first EGR valve, and the system may include a second EGR valve **235**. When the first valve **234** is open and the second valve **235** is closed, exhaust may be routed from the donor cylinders to the EGR cooler **236** and/or additional elements prior to being routed to the intake passage.

The first valve **234** and second valve **235** may be on/off valves controlled by a control unit, such as control unit **148** of FIG. **1**, (for turning the flow of EGR on or off), or they may control a variable amount of EGR, for example. In some examples, the first valve **234** may be actuated such that an EGR amount is reduced (exhaust gas flows from the donor manifold to the exhaust passage). In other examples, the first valve **234** may be actuated such that the EGR amount is increased (e.g., exhaust gas flows from the donor manifold to the EGR passage).

In such a configuration, the second valve **235** is operable to route exhaust from the donor cylinders to the exhaust passage **205** of the engine and the first valve **234** is operable to route exhaust from the donor cylinders to the intake passage of the engine. As such, the second valve **235** may be referred to as an EGR bypass valve, while the first valve **234** may be referred to as an EGR metering valve. In the embodiment shown in FIG. **2**, the first valve **234** and the second valve **235** may be engine oil, or hydraulically, actuated valves, for example, with a shuttle valve (not shown) to modulate the engine oil. In some examples, the valves may be actuated such that one of the first and second valves is normally open and the other is normally closed. In other examples, the first and second valves may be pneumatic valves, electric valves, or another suitable valve.

The engine system further includes a muffler **250** positioned along the exhaust passage **205** downstream of the second turbocharger **216**. The muffler **250** may reduce exhaust noise, for example, by absorption or through resonating chambers tuned to cause destructive interference of the sound waves.

Thus, as explained above with respect to FIGS. **1** and **2**, an engine may receive intake air and expel exhaust gas. The engine may be comprised of a plurality of cylinders that receive fuel for combustion with the intake air. FIG. **7** depicts an embodiment of a combustion chamber, or cylinder **700**, of a multi-cylinder internal combustion engine, such as the engine described above with reference to FIG. **1** and/or FIG. **2**. The cylinder may be defined by a cylinder head **701**, housing the intake and exhaust valves and liquid fuel injector, described below, and a cylinder block **703**.

The engine may be controlled at least partially by a control system including controller **748** which may be in further communication with a vehicle system, such as the locomotive described above with reference to FIG. **1**. As described above, the controller may further receive signals from various engine sensors including, but not limited to, engine speed, engine load, boost pressure, exhaust pressure, ambient pressure, CO2 levels, exhaust temperature, NOx emission, engine coolant temperature (ECT) from temperature sensor **730** coupled to cooling sleeve **728**, etc. Correspondingly, the controller may control the vehicle system by sending commands to various components such as alternator, cylinder valves, throttle, fuel injectors, etc.

The cylinder (i.e., combustion chamber) may include cylinder liner **704** with a piston **706** positioned therein. The piston may be coupled to a crankshaft **708** so that reciprocating motion of the piston is translated into rotational motion of the crankshaft. In some embodiments, the engine may be a four-stroke engine in which each of the cylinders fires in a firing order during two revolutions of the crankshaft. In other embodiments, the engine may be a two-stroke engine in which each of the cylinders fires in a firing order during one revolution of the crankshaft.

The cylinder receives intake air for combustion from an intake including an intake passage **710**. The intake passage receives intake air via an intake manifold. The intake passage may communicate with other cylinders of the engine in addition to the cylinder, for example, or the intake passage may communicate exclusively with the cylinder.

Exhaust gas resulting from combustion in the engine is supplied to an exhaust including an exhaust passage **712**. Exhaust gas flows through the exhaust passage, to a turbocharger in some embodiments (not shown in FIG. **7**) and to atmosphere, via an exhaust manifold. The exhaust passage may further receive exhaust gases from other cylinders of the engine in addition to the cylinder, for example.

Each cylinder of the engine may include one or more intake valves and one or more exhaust valves. For example, the cylinder is shown including at least one intake poppet valve **714** and at least one exhaust poppet valve **716** located in an upper region of cylinder. In some embodiments, each cylinder of the engine, including the cylinder, may include at least two intake poppet valves and at least two exhaust poppet valves located at the cylinder head.

The intake valve may be controlled by the controller via an actuator **718**. Similarly, the exhaust valve may be controlled by the controller via an actuator **720**. During some conditions, the controller may vary the signals provided to the actuators to control the opening and closing of the respective intake and exhaust valves. The position of the intake valve and the exhaust valve may be determined by respective valve position sensors **722** and **724**, respectively, and/or by cam position sensors. The valve actuators may be of the electric valve actuation type or cam actuation type, or a combination thereof, for example.

The intake and exhaust valve timing may be controlled concurrently or any of a possibility of variable intake cam timing, variable exhaust cam timing, dual independent variable cam timing or fixed cam timing may be used. In other embodiments, the intake and exhaust valves may be controlled by a common valve actuator or actuation system, or a variable valve timing actuator or actuation system. Further, the intake and exhaust valves may by controlled to have variable lift by the controller based on operating conditions.

In still further embodiments, a mechanical cam lobe may be used to open and close the intake and exhaust valves. Additionally, while a four-stroke engine is described above, in some embodiments a two-stroke engine may be used, where the intake valves are dispensed with and ports in the cylinder wall are present to allow intake air to enter the cylinder as the piston moves to open the ports. This can also extend to the exhaust, although in some examples exhaust valves may be used.

In some embodiments, each cylinder of the engine may be configured with one or more fuel injectors for providing fuel thereto. As a non-limiting example, FIG. **7** shows the cylinder including a fuel injector **726**. The fuel injector is shown coupled directly to the cylinder for injecting fuel directly therein. In this manner, the fuel injector provides what is known as direct injection of a fuel into the combustion cylinder. The fuel may be delivered to the fuel injector from a first, liquid fuel system **732**, including a fuel tank, fuel pumps, and a fuel rail. In one example, the fuel is diesel fuel that is combusted in the engine through compression ignition. In other non-limiting embodiments, the fuel may be gasoline, kerosene, biodiesel, or other petroleum distillates of similar density through compression ignition (and/or spark ignition).

Further, each cylinder of the engine may be configured to receive gaseous fuel (e.g., natural gas) alternative to or in addition to diesel fuel. The gaseous fuel may be provided to the cylinder via the intake manifold in one example. As shown in FIG. **7**, the intake passage may receive a supply of gaseous fuel from a second, gaseous fuel system **734**, via one or more gaseous fuel lines, pumps, pressure regulators, etc., located upstream of the cylinder. In some embodiments, the gaseous fuel system may be located remotely from the engine, such as on a different vehicle (e.g., on a fuel tender car), and the gaseous fuel may be supplied to the engine via one or more fuel lines that traverse the separate vehicles. However, in other embodiments the gaseous fuel system may be located on the same vehicle as the engine.

A plurality of gas admission valves, such as gas admission valve **736**, may be configured to supply gaseous fuel from the gaseous fuel system to each respective cylinder via respective intake passages. For example, a degree and/or duration of opening of the gas admission valve may be adjusted to regulate an amount of gaseous fuel provided to the cylinder. As such, each respective cylinder may be provided with gaseous fuel from an individual gas admission valve, allowing for individual cylinder control in the amount of gaseous fuel provided to the cylinders. However, in some embodiments, a single-point fumigation system may be used, where gaseous fuel is mixed with intake air at a single point upstream of the cylinders. In such a configuration, each cylinder may be provided with substantially similar amounts of gaseous fuel. To regulate the amount of gaseous fuel provided by the single-point fumigation system, in some examples a gaseous fuel control valve may be positioned at a junction between a gaseous fuel supply line and the engine intake air supply line or intake manifold. The gaseous fuel control valve degree and/or duration of opening may be adjusted to regulate the amount of gaseous fuel admitted to the cylinders. In other examples, the amount of gaseous fuel admitted to the cylinders in the single-point fumigation system may be regulated by another mechanism, such as control of a gaseous fuel regulator, via control of a gaseous fuel pump, etc.

Thus, in one embodiment, system for an engine comprises an exhaust passage through which exhaust gas flows from the engine, and a turbocharger with a turbine positioned in the exhaust passage. The system further comprises an exhaust gas treatment system disposed in the exhaust passage upstream of the turbocharger, the exhaust gas treatment system including at least one exhaust gas treatment device and a bypass with a bypass valve, the bypass valve configured to be adjusted to reduce exhaust gas flow through the exhaust gas treatment system in response to a transient engine operating condition.

In this way, the transient response of the engine may be improved, as the bypass valve of the exhaust gas treatment system may be opened during transient conditions in which a load on the engine is changing. Further, because the exhaust gas treatment system is positioned upstream of the two-stage turbocharger, specific fuel consumption may be improved while particulate matter is reduced.

FIG. **3** shows an example bar graph **300** illustrating the effect of the position of an exhaust gas treatment system in an engine system on average specific fuel consumption (SFC) during a duty cycle. As used herein, the specific fuel consumption is the rate of fuel consumption divided by power. The bar **302** of graph **300** shows a baseline specific fuel consumption. In this example, the baseline specific fuel consumption may be the average specific fuel consumption over a duty cycle, for example, in an engine system without an exhaust gas treatment system. Thus, the bar **302** shows specific fuel consumption for an engine system with no exhaust treatment system positioned upstream of a turbocharger and no exhaust gas treatment system positioned downstream of the turbocharger.

The bar **304** shows specific fuel consumption for an engine system with a pre-turbo exhaust gas treatment system. As depicted, the specific fuel consumption is higher for an engine system with an exhaust gas treatment system located upstream of the turbocharger than an engine system with no exhaust gas treatment system. The increase in specific fuel consumption may be due to a pressure drop in the exhaust passage created by the exhaust gas treatment system, for example. Because the pressure drop may induce a backpressure on the engine, the specific fuel consumption may increase.

The bar **306** shows specific fuel consumption for an engine system with a post-turbo exhaust gas treatment system. As illustrated, the specific fuel consumption is higher for an engine system with an exhaust gas treatment system positioned downstream of the turbocharger than an engine system with no exhaust gas treatment system or an exhaust gas treatment system positioned upstream of the turbocharger. The pressure drop created by the post-turbo exhaust gas treatment system may be the same as the pressure drop created by the pre-turbo exhaust gas treatment system. However, because a pressure drop downstream of the turbocharger is increased proportionally across the turbine of the turbocharger, the post-turbo exhaust gas treatment system may result in a greater backpressure on the engine and a greater specific fuel consumption.

Thus, by positioning an exhaust gas treatment system upstream of a turbocharger in an engine system, specific fuel consumption may be reduced.

An embodiment relates to a method, e.g., a method for controlling an engine system, such as the engine system **110** described above with reference to FIG. **1** or the engine system **200** described above with reference to FIG. **2**. The method comprises receiving information of a changed power setting of an engine. (For example, the information may be received responsive to changing a power setting of the engine, and identifying the changed power setting.) The method further comprises adjusting a bypass valve of a bypass of an exhaust gas treatment system in response to the changed power setting. The exhaust gas treatment system is disposed upstream of a turbocharger turbine in an exhaust passage of the engine.

Referring now to FIG. **4**, a flow chart illustrating a method **400** for an engine system with a pre-turbo exhaust gas treatment system with a bypass, such as the engine system **110** described above with reference to FIG. **1** or the engine system **200** described above with reference to FIG. **2**, is shown. Specifically, the method **400** determines if a power setting of the engine has been changed resulting in a transient engine condition, and adjusts the bypass valve accordingly.

At **402** of method **400**, a power setting is changed, thereby initiating transient engine operating conditions. As described above, the power setting may be changed when a notch of a notched throttle is shifted from a first notch corresponding to a first power setting to a second notch corresponding to a second, different power setting (e.g., from notch **7** to notch **8**). As a first example, the second power setting may correspond to a higher power level than the first power setting. As a second example, the second power setting may correspond to a lower power level than the first power setting (e.g., a down-notch). In some examples, the power setting may be changed by an operator of the vehicle in which the engine system is positioned. In other examples, the power setting may be changed based on a trip plan, as described above.

At **404** of method **400**, the changed power setting is identified. The controller may identify the notch setting based on communication from a notch sensor located on the notched throttle, for example.

At **406** of method **400**, the bypass valve on the bypass around the exhaust gas treatment device is opened. By opening the bypass valve, the exhaust flow through the exhaust treatment system may be substantially reduced. In this way, an amount of energy absorbed by the exhaust gas treatment system is reduced, thereby increasing an amount of energy available to the turbocharger for boost. In some embodiments in which the turbocharger has a wastegate, the wastegate may be closed in response to the transient operating conditions. In this manner, an amount of boost generated by the turbocharger may be further increased, as substantially all the exhaust gas is passing through the turbocharger and not around the turbocharger.

Once the bypass valve is opened, method **400** proceeds to **408** where it is determined if the EGR valve is open. If it is determined that the EGR valve is closed, and exhaust gas is not entering the EGR system, the method ends. On the other hand, if it is determined that the EGR valve is open, and a portion of exhaust gas is being recirculated to the engine, method **400** continues to **410** where the EGR valve is closed. In this way, an amount of energy that is available to the turbocharger for boost is increased, as substantially all of the exhaust gas exiting the engine is passing through the turbocharger.

It should be noted, the bypass valve on the bypass around the exhaust gas treatment device may be closed when transient conditions end. For example, the bypass valve on the bypass around the exhaust gas treatment device may be closed when engine output settles to a steady state value.

Thus, during transient engine conditions, such as when the notched throttle is shifted from one power setting to another power setting, the bypass valve of the exhaust gas treatment system may be opened so that the exhaust gas flow from the engine bypasses the exhaust gas treatment device. Further, during the transient engine operating conditions, the EGR valve may be closed. In this manner, the transient engine response may be improved, as a reduced portion of energy from the hot exhaust gas is not dissipated to the exhaust gas treatment device and a portion of exhaust gas is not recirculated to the engine. Instead, substantially all of the exhaust gas flow through the turbocharger, and the energy may be utilized by the turbocharger to increase an amount of boost, thereby increasing the pressure of the charge air delivered to the cylinders of the engine such that a time it takes the engine to speed up may be reduced.

FIG. **5** shows an example graph **500** illustrating torque over time under transient engine operating conditions for various engine systems. The curve **502** shows a baseline torque curve for an engine system without an exhaust gas treatment system (e.g., there is no exhaust gas treatment system located upstream of the turbocharger and there is no exhaust gas treatment system located downstream of the turbocharger). The curve **504** shows a torque curve for an engine system with an exhaust gas treatment system positioned upstream of the turbocharger. The curve **506** shows a torque curve for an engine system with an exhaust gas treatment system positioned upstream of the turbocharger and including a bypass valve that is opened during the transient operating conditions.

As shown by graph **500**, the transient response time for an engine system without an exhaust gas treatment system and an engine system with a pre-turbo exhaust gas treatment system with a bypass valve that is opened during transient conditions is substantially the same. The torque for curves **502** and **506** increases at a similar rate. In contrast, the transient response time for an engine system with a pre-turbo exhaust gas treatment system is greater than the transient response time for an engine system without an exhaust gas treatment system and an engine system with a pre-turbo exhaust gas treatment system with a bypass valve that is opened during transient conditions.

Thus, by including a valved bypass around the pre-turbo exhaust gas treatment system, a transient response of the engine may be improved. Further, as described above, by positioning the exhaust gas treatment system upstream of the turbocharger, specific fuel consumption of the engine may be reduced during steady state conditions.

Continuing to FIG. **6**, a method **600** for an engine system with a pre-turbo exhaust gas treatment system with a bypass, such as the engine system **110** described above with reference to FIG. **1** or the engine system **200** described above with reference to FIG. **2**, is shown. Specifically, method **600** determines environmental operating conditions of the engine and adjusts the bypass valve accordingly.

At **602** of method **600**, engine operating conditions are determined Engine operating conditions may include load conditions, environmental conditions (e.g., tunneling operation, ambient temperature, ambient pressure, and the like), and the like.

Once the operating conditions are determined, method **600** proceeds to **604** where it is determined if an ambient temperature is greater than a threshold. The threshold may be a temperature related to tunneling operation or above average temperatures for a region in which the vehicle in which the engine system is positioned is travelling. If it is determined that the ambient temperature is less than the threshold, method **600** moves to **612** and current engine operation is continued. As an example, if the bypass valve is closed, the bypass valve remains closed such that the exhaust gas treatment system may continue to reduce particulate matter emissions.

On the other hand, if it is determined that the ambient temperature exceeds the threshold, method **600** continues to **606** where the bypass valve is opened. In this manner, a flow of exhaust gas through the exhaust gas treatment device may be reduced, for example, such that a temperature of the exhaust gas treatment device does not exceed a threshold above which degradation of the exhaust gas treatment device may occur.

Thus, an engine system may include a pre-turbo exhaust gas treatment system with an exhaust gas treatment device and a valved bypass. The bypass may be adjusted during various engine operation conditions. In one example, the bypass may be opened to reduce the flow of exhaust gas through the exhaust gas treatment device in order to reduce a transient response of the engine. In another example, the bypass may be opened to reduce the flow of exhaust gas through the exhaust gas treatment device in order to cool the exhaust gas treatment device. Further, by positioning the exhaust gas treatment device upstream of the turbocharger, specific fuel consumption may be reduce while particulate emissions are reduced.

Continuing to FIG. **8**, a method **800** for an engine system with a pre-turbo exhaust gas treatment system with a bypass, such as the engine system **110** described above with reference to FIG. **1** or the engine system **200** described above with reference to FIG. **2**, is shown. Specifically, method **800** determines a fuel type supplied to the engine and adjusts the bypass valve accordingly. As such, method **800** may be carried out in engine system **110** and/or **200**, where the engine includes a plurality of cylinders configured to receive more than type of fuel, such as cylinder **700** of FIG. **7**.

At **802** of method **800**, engine operating conditions are determined Engine operating conditions may include load conditions, environmental conditions (e.g., tunneling operation, ambient temperature, ambient pressure, and the like), fuel parameters (e.g., relative fuel levels in each respective fuel system), and the like.

At **804**, method **800** identifies which type(s) of fuel is currently supplied to the engine. As explained above with respect to FIG. **7**, the engine may be configured to operate with only a first, liquid fuel (e.g., diesel), operate with only a second, gaseous fuel (e.g., natural gas), and/or operate with both the first and second fuels. Which fuel(s) are supplied to the engine may depend on engine load, operator desired fuel economy, fuel availability, and/or other parameters. In one example, the engine may operate with only liquid fuel during low load conditions (e.g., idling) and operate with both liquid fuel and gaseous fuel during medium and high load conditions.

At **806**, method **800** includes adjusting the bypass valve based on the fuel type(s) supplied to the engine. This may include opening the bypass valve to route exhaust around the exhaust gas treatment system. In some examples, the exhaust gas may be routed through the bypass and around the exhaust gas treatment system when the engine is operating with only liquid fuel. For example, emissions may be suitably met by operation with EGR, and hence the exhaust gas may be routed directly to the turbocharger(s) to increase engine power and/or responsiveness. Then, responsive to a change from operation with only liquid fuel to operation with both liquid and gaseous fuel, the bypass valve may be closed such that exhaust gas is routed through the exhaust gas treatment system. In this way, emissions produced by combustion of the gaseous fuel may treated by the exhaust gas treatment system.

In other examples, the exhaust gas may be routed through the bypass and around the exhaust gas treatment system when the engine is operating with both liquid fuel and gaseous fuel. The gaseous fuel may produce fewer emissions upon combustion than the liquid fuel, for example, and hence when a substantial proportion of engine power is derived from the gaseous fuel (e.g., 80 or 90%), it may be possible to dispense with treatment of the exhaust gas via the exhaust gas treatment system, in order to increase engine power and/or responsiveness. Then, responsive to a change from operation with both liquid and gaseous fuel to operation with only liquid fuel, the bypass valve may be closed such that exhaust gas is routed through the exhaust gas treatment system. In this way, emissions produced by the combustion of the liquid fuel may be treated by the exhaust gas treatment system.

In still further examples, the bypass valve may be adjusted based on both fuel type and mass flow through the EGR system (which may be determined based on sensor signals from an intake oxygen sensor, or based on the position of one or more EGR valves of the EGR system and exhaust pressure and/or mass flow). For example, if the engine is operating with liquid fuel only and EGR mass flow is above a threshold, the bypass valve may be opened so that the exhaust gas bypasses the exhaust gas treatment system. However, if the EGR mass flow drops below the threshold, the bypass valve may be closed so that at least some of the exhaust gas passes through the exhaust gas treatment system. In doing so, emissions may be maintained during conditions where EGR flow is not high enough to control emissions.

Additionally, during adjustment of the bypass valve based on fuel type, an additional adjustment to the bypass valve position may be made based on ambient and/or exhaust temperature, as explained above with respect to FIG. **6**, such that exhaust gas treatment system temperature may be regulated.

Thus, the systems and methods described above provide for a system for an engine. In one example, the system includes an exhaust passage through which exhaust gas is configured to flow from the engine; a turbocharger with a turbine positioned in the exhaust passage; an exhaust gas treatment system disposed in the exhaust passage upstream of the turbine, the exhaust gas treatment system including at least one exhaust gas treatment device and a bypass with a bypass valve, the bypass valve configured to be adjusted to reduce exhaust gas flow through the exhaust gas treatment system in response to a transient engine operating condition; and an exhaust gas recirculation system coupled between the exhaust passage and an intake passage of the engine, the exhaust gas recirculation system including an exhaust gas recirculation passage and at least one exhaust gas recirculation valve, an inlet of the exhaust gas recirculation system positioned upstream of the exhaust gas treatment system.

The bypass valve may be further configured to be adjusted to reduce exhaust gas flow through the exhaust gas treatment system in response to a temperature of the exhaust gas treatment system exceeding a threshold.

In one example, the at least one exhaust gas treatment device includes one or more of a diesel oxidation catalyst and a particulate oxidation catalyst. In other examples, the at least one exhaust gas treatment device additionally or alternatively includes one or more of an SCR device, NOx trap, or other device.

In an example, the at least one exhaust gas recirculation valve comprises a bypass valve coupling an exhaust manifold of the engine to the exhaust passage and a metering valve coupling the exhaust manifold to the exhaust gas recirculation passage, and wherein the exhaust gas recirculation system is configured for the metering valve to be closed during the transient engine operating condition. The exhaust manifold may be a first exhaust manifold, and the engine may include a first group of cylinders coupled to the first exhaust manifold and a second group of cylinders coupled to a second exhaust manifold, the second exhaust manifold coupled to the exhaust passage (and in some examples, the second exhaust manifold is coupled exclusively to the exhaust passage).

The system may further comprise a control unit for adjusting the bypass valve, wherein the control unit is configured to control the bypass valve to an open position in order to reduce exhaust gas flow through the exhaust gas treatment system in response to the transient operating condition.

The system may further comprise a notched throttle, the notched throttle having a plurality of notches, each notch corresponding to a different power setting of the engine, wherein the transient engine operating condition is initiated by a shift of the notched throttle from one notch to another notch.

The system may further comprise a control unit for adjusting the bypass valve, wherein the control unit is configured to open the bypass valve in response to an ambient temperature exceeding a threshold.

The engine may be configured to combust a liquid fuel and a gaseous fuel, and the transient operating condition may comprise engine operation with only liquid fuel delivered to the engine.

Another example of a system includes an engine; an exhaust passage through which exhaust gas is configured to flow from the engine; a turbocharger with a turbine positioned in the exhaust passage; a notched throttle, the notched throttle having a plurality of notches, each notch corresponding to a different power setting of the engine; and an exhaust gas treatment system disposed in the exhaust passage, the exhaust gas treatment system including at least one exhaust gas treatment device and a bypass with a bypass valve, the bypass valve configured to be adjusted to reduce exhaust gas flow through the exhaust gas treatment system in response to a shift of the notched throttle from one notch to another, lower notch.

The bypass valve may be configured to be adjusted to increase exhaust gas flow through the exhaust gas treatment device in response to a shift of the notched throttle from one notch to another, higher notch.

The engine may be configured to combust a first fuel and a second fuel, and the bypass valve may be configured to be adjusted to reduce exhaust gas flow through the exhaust gas treatment system in response engine operation with only the first fuel, and the bypass valve may be configured to be adjusted to increase exhaust gas flow through the exhaust gas treatment system in response to engine operation with the second fuel. In one example, the first fuel is diesel and the second fuel is natural gas.

In an example, the exhaust gas treatment system is disposed in the exhaust passage upstream of the turbine. The exhaust gas treatment system may be a first exhaust gas treatment system, and the system may further comprise a second exhaust gas treatment system disposed in the exhaust passage downstream of the turbine, the second exhaust gas treatment system including at least one exhaust gas treatment device.

An example of a vehicle system includes an engine having a plurality of cylinders configured to combust one or both of a first fuel and a second fuel; an exhaust passage through which exhaust gas flows from the engine; a throttle for controlling a power setting of the engine; a turbocharger with a turbine positioned in the exhaust passage; an exhaust gas treatment system disposed in the exhaust passage upstream of the turbine, the exhaust gas treatment system including a diesel oxidation catalyst and a particulate oxidation catalyst and a bypass with a bypass valve; and a controller configured to identify a change in the power setting of the engine due to a shift of the throttle, and in response to the change in the power setting, at least partially open the bypass valve to reduce flow through the exhaust gas treatment system, the controller further configured to adjust the bypass valve based on whether the first fuel, second fuel, or both the first fuel and second fuel is being combusted in the plurality of cylinders.

The controller may be further configured to adjust the bypass valve based on a temperature of the exhaust gas treatment system.

The vehicle system may further comprise an exhaust gas recirculation system with an exhaust gas recirculation passage coupled between the exhaust passage and an intake passage of the engine, and an exhaust gas recirculation valve operably disposed in the exhaust gas recirculation passage, wherein the controller is further configured to selectively at least partially close the exhaust gas recirculation valve in response to the change in the power setting of the engine.

In an example, the throttle is a notched throttle including a plurality of notches each corresponding to a different power setting of the engine; and wherein the controller is configured to identify the change in the power setting of the engine due to a shift of the notched throttle from one notch to another notch. The controller may be further configured to identify an ambient temperature, and to at least partially open the bypass valve in response to the ambient temperature exceeding a threshold.

As used herein, an element or step recited in the singular and proceeded with the word “a” or “an” should be understood as not excluding plural of said elements or steps, unless such exclusion is explicitly stated. Furthermore, references to “one embodiment” of the present invention are not intended to be interpreted as excluding the existence of additional embodiments that also incorporate the recited features. Moreover, unless explicitly stated to the contrary, embodiments “comprising,” “including,” or “having” an element or a plurality of elements having a particular property may include additional such elements not having that property. The terms “including” and “in which” are used as the plain-language equivalents of the respective terms “comprising” and “wherein.” Moreover, the terms “first,” “second,” and “third,” etc. are used merely as labels, and are not intended to impose numerical requirements or a particular positional order on their objects.

This written description uses examples to disclose the invention, including the best mode, and also to enable a person of ordinary skill in the relevant art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those of ordinary skill in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

The invention claimed is:

1. A system for an engine, comprising:

an exhaust passage through which exhaust gas is configured to flow from the engine;

a turbocharger with a turbine positioned in the exhaust passage;

an exhaust gas treatment system disposed in the exhaust passage upstream of the turbine, the exhaust gas treatment system including at least one exhaust gas treatment device and a bypass with a bypass valve, the bypass valve configured to be adjusted to control exhaust gas flow through the exhaust gas treatment system;

an exhaust gas recirculation system coupled between the exhaust passage and an intake passage of the engine, the exhaust gas recirculation system including an exhaust gas recirculation passage and at least one exhaust gas recirculation valve, an inlet of the exhaust gas recirculation system positioned upstream of the exhaust gas treatment system;

a control unit configured to control the bypass valve to reduce the exhaust gas flow through the exhaust gas treatment s stem in response to a transient operatin condition; and

a throttle having plural throttle settings, wherein the control unit is configured to automatically control the throttle based on a trip plan, and wherein the transient engine operating condition is initiated by a shift from one of the throttle settings to another of the throttle settings.

2. A system for an engine, comprising:

an exhaust passage through which exhaust gas is configured to flow from the engine;

turbocharger with a turbine positioned in the exhaust passage;

an exhaust gas treatment system disposed in the exhaust passage upstream of the turbine, the exhaust gas treatment system including at least one exhaust gas treatment device and a bypass with a bypass valve, the bypass valve configured to be adjusted to reduce exhaust gas flow through the exhaust gas treatment system in response to a transient engine operating condition, and the bypass valve is further configured to be adjusted to reduce exhaust gas flow through the exhaust gas treatment system in response to a temperature of the exhaust gas treatment system exceeding a threshold; and

an exhaust as recirculation system coupled between the exhaust passage and an intake passage of the engine, the exhaust gas recirculation system including an exhaust gas recirculation passage and at least one exhaust gas recirculation valve, an inlet of the exhaust gas recirculation system positioned upstream of the exhaust gas treatment system.

3. The system of claim **2**, wherein the at least one exhaust gas treatment device includes one or more of a diesel oxidation catalyst and a particulate oxidation catalyst.

4. The system of claim **2**, further comprising a control unit for adjusting the bypass valve, wherein the control unit is configured to control the bypass valve to an open position in order to reduce the exhaust gas flow through the exhaust gas treatment system in response to the transient operating condition.

5. The system of claim **2**, further comprising a notched throttle, the notched throttle having a plurality of notches, each notch corresponding to a different power setting of the engine, wherein the transient engine operating condition is initiated by a shift of the notched throttle from one notch to another notch.

6. A system for an engine, comprising:

an exhaust passage through which exhaust gas is configured to flow from the engine;

a turbocharger with a turbine positioned in the exhaust passage;

an exhaust gas treatment system disposed in the exhaust passage upstream of the turbine, the exhaust gas treatment system including at least one exhaust gas treatment device and a bypass with a bypass valve, the bypass valve configured to adjusted to reduce exhaust gas flow through the exhaust gas treatment system in response to a transient engine operating condition; and

an exhaust gas recirculation system coupled between the exhaust passage and an intake passage of the engine the exhaust gas recirculation system including an exhaust gas recirculation passage and at least one exhaust gas recirculation valve, an inlet of the exhaust gas recirculation system positioned upstream of the exhaust gas treatment system,

wherein the at least one exhaust gas recirculation valve comprises a bypass valve coupling an exhaust manifold of the engine to the exhaust passage and a metering valve coupling the exhaust manifold to the exhaust gas recirculation passage, and wherein the exhaust gas recirculation system is configured for the metering valve to be closed during the transient engine operating condition.

7. The system of claim **6**, wherein the exhaust manifold is a first exhaust manifold, and wherein the engine includes a first group of cylinders coupled to the first exhaust manifold and a second group of cylinders coupled to a second exhaust manifold, the second exhaust manifold coupled to the exhaust passage.

8. A system for an engine, comprising:

an exhaust passage through which exhaust gas is configured to flow from the engine;

turbocharger with a turbine positioned in the exhaust passage;

an exhaust gas treatment system disposed in the exhaust passage upstream of the turbine, the exhaust gas treatment system including at least one exhaust gas treatment device and a bypass with a bypass valve, the bypass valve configured to be adjusted to reduce exhaust gas flow through the exhaust gas treatment system in response to a transient engine operating condition,

an exhaust gas recirculation system coupled between the exhaust passage and an intake passage of the engine the exhaust gas recirculation system including an exhaust gas recirculation passage and at least one exhaust gas recirculation valve, an inlet of the exhaust gas recirculation system positioned upstream of the exhaust gas treatment system; and

a control unit for adjusting the bypass valve, wherein the control unit is configured to open the bypass valve in response to an ambient temperature exceeding a threshold.

9. A system comprising:

an engine, wherein the engine is configured to combust a liquid fuel and a gaseous fuel;

an exhaust passage through which exhaust gas is configured to flow from the engine;

a turbocharger with a turbine positioned in the exhaust passage;

an exhaust gas treatment system disposed in the exhaust passage upstream of the turbine, the exhaust gas treatment system including at least one exhaust gas treatment device and a bypass with a bypass valve, the bypass valve configured to be adjusted to reduce exhaust gas flow through the exhaust gas treatment system in response to a transient engine operating condition; and

an exhaust gas recirculation system coupled between the exhaust passage and an intake passage of the engine, the exhaust gas recirculation system including an exhaust gas recirculation passage and at least one exhaust gas recirculation valve, an inlet of the exhaust gas recirculation system positioned upstream of the exhaust gas treatment system, and wherein the transient operating condition comprises engine operation with only liquid fuel delivered to the engine.

10. A rail vehicle system, comprising:

an engine;

an exhaust passage through which exhaust gas is configured to flow from the engine;

a turbocharger with a turbine positioned in the exhaust passage;

a notched throttle, the notched throttle having a plurality of discrete notches, each notch corresponding to a different discrete power se ting of the engine; and

an exhaust gas treatment system disposed in the exhaust passage, the exhaust gas treatment system including at least one exhaust gas treatment device and a bypass with a bypass valve, the bypass valve configured to be adjusted to reduce exhaust gas flow through the exhaust gas treatment system in response to a shift of the notched throttle from one notch to another, higher notch.

11. The system of claim **10**, wherein the bypass valve is configured to be adjusted to increase exhaust gas flow through the exhaust gas treatment device in response to a shift of the notched throttle from one notch to another, lower notch.

12. The system of claim **10**, wherein the exhaust gas treatment system is disposed in the exhaust passage upstream of the turbine.

13. The system of claim **12**, wherein the exhaust gas treatment system is a first exhaust gas treatment system, and further comprising a second exhaust gas treatment system disposed in the exhaust passage downstream of the turbine, the second exhaust gas treatment system including at least one exhaust gas treatment device.

14. The rail vehicle system of claim **10**, wherein the notched throttle has exactly eight notches.

15. The rail vehicle system of claim **10**, further comprising an exhaust gas recirculation system coupled between the exhaust passage and an intake passage of the engine, the exhaust gas recirculation system having an exhaust gas recirculation valve configured to be controlled to reduce exhaust gas recirculated from the exhaust passage to the intake passage responsive to the shift of the notched throttle.

16. A system comprising:

an engine, wherein the engine is configured to combust a first fuel and a second fuel;

an exhaust passage through which exhaust gas is configured to flow from the engine;

a turbocharger with a turbine positioned in the exhaust passage;

a notched throttle, the notched throttle having a plurality of notches each notch corresponding to a different power setting of the engine; and

an exhaust gas treatment system disposed in the exhaust passage, the exhaust gas treatment system including at least one exhaust gas treatment device and a bypass with a bypass valve, the bypass valve configured to be adjusted to reduce exhaust gas flow through the exhaust gas treatment system in response to a shift of the notched throttle from one notch to another, higher notch, wherein the bypass valve is configured to be adjusted to reduce exhaust gas flow through the exhaust gas treatment system in response engine operation with only the first fuel, and wherein the bypass valve is configured to be adjusted to increase exhaust gas flow through the exhaust gas treatment system in response to engine operation with the second fuel.

17. The system of claim **16**, wherein the first fuel is diesel and the second fuel is natural gas.

18. A vehicle system, comprising:

an engine having a plurality of cylinders configured to combust one or both of a first fuel and a second fuel;

an exhaust passage through which exhaust gas flows from the engine;

a throttle for controlling a power setting of the engine;

a turbocharger with a turbine positioned in the exhaust passage;

an exhaust gas treatment system disposed in the exhaust passage upstream of the turbine, the exhaust gas treatment system including a diesel oxidation catalyst and a particulate oxidation catalyst and a bypass with a bypass valve; and

a controller configured to identify a change in the power setting of the engine due to a shift of the throttle, and in response to the change in the power setting, at least partially open the bypass valve to reduce flow through the exhaust gas treatment system, the controller further configured to adjust the bypass valve based on whether the first fuel, second fuel, or both the first fuel and second fuel is being combusted in the plurality of cylinders.

19. The vehicle system of claim **18**, wherein the throttle is a notched throttle including a plurality of notches each corresponding to a different power setting of the engine; and wherein the controller is configured to identify the change in the power setting of the engine due to a shift of the notched throttle from one notch to another notch.

20. The vehicle system of claim **18**, wherein the control is further configured to identify an ambient temperature, and to at least partially open the bypass valve in response to the ambient temperature exceeding a threshold.

21. The vehicle system of claim **18**, wherein the controller is further configured to adjust the bypass valve based on a temperature of the exhaust gas treatment system.

22. The vehicle system of claim **18**, further comprising an exhaust gas recirculation system with an exhaust gas recirculation passage coupled between the exhaust passage and an intake passage of the engine, and an exhaust gas recirculation valve operably disposed in the exhaust gas recirculation passage, wherein the controller is further configured to selectively at least partially close the exhaust gas recirculation valve in response to the change in the power setting of the engine.

23. A system, comprising:

an engine having a plurality of cylinders, wherein the plurality of cylinders includes one or more non-donor cylinders that supply exhaust gas exclusively to a non-donor cylinder exhaust manifold, and wherein the plurality of cylinders includes one or more donor cylinders that supply exhaust gas exclusively to a donor cylinder exhaust manifold;

an exhaust passage through which exhaust gas is configured to flow from the engine;

a turbocharger with a turbine positioned in the exhaust passage;

an exhaust gas treatment system disposed in the exhaust passage upstream of the turbine, the exhaust gas treatment system including at least one exhaust gas treatment device and a bypass with a bypass valve, the bypass valve configured to be adjusted to reduce exhaust gas flow through the exhaust gas treatment system in response to a transient engine operating condition; and

an exhaust gas recirculation system coupled between the exhaust passage and an intake passage of the engine, the exhaust gas recirculation system including an exhaust gas recirculation passage and at least one exhaust gas recirculation valve, an inlet of the exhaust gas recirculation system positioned upstream of the exhaust gas treatment system.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 9,404,448 B2
APPLICATION NO. : 14/803928
DATED : August 2, 2016
INVENTOR(S) : Gokhale

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the Title Page, in item (56), under "OTHER PUBLICATIONS", in Column 2, Line 1, delete "Giles" and insert -- Gilles --, therefor.

In the Specification

In Column 1, Line 7, delete "2011," and insert -- 2011, now Pat. No. 9,120,489, --, therefor.

In Column 14, Line 45, delete "determined" and insert -- determined. --, therefor.

In the Claims

In Column 19, Line 3, in Claim 1, delete "s stem in response to a transient operatin" and insert -- system in response to a transient operating --, therefor.

In Column 19, Line 14, in Claim 2, delete "turbocharger" and insert -- a turbocharger --, therefor.

In Column 19, Line 27, in Claim 2, delete "as" and insert -- gas --, therefor.

In Column 19, Line 58, in Claim 6, delete "configured to" and insert -- configured to be --, therefor.

In Column 19, Line 62, in Claim 6, delete "engine" and insert -- engine, --, therefor.

In Column 20, Line 18, in Claim 8, delete "turbocharger" and insert -- a turbocharger --, therefor.

In Column 20, Line 28, in Claim 8, delete "engine" and insert -- engine, --, therefor.

In Column 21, Line 3, in Claim 10, delete "se ting" and insert -- setting --, therefor.

Signed and Sealed this
Eleventh Day of October, 2016

Michelle K. Lee

Michelle K. Lee
Director of the United States Patent and Trademark Office

In the Claims

In Column 21, Line 11, in Claim 11, delete “The system” and insert -- The rail vehicle system --, therefor.

In Column 21, Line 15, in Claim 12, delete “The system” and insert -- The rail vehicle system --, therefor.

In Column 21, Line 18, in Claim 13, delete “The system” and insert -- The rail vehicle system --, therefor.

In Column 21, Line 33, in Claim 16, delete “A system” and insert -- A system, --, therefor.

In Column 21, Line 41, in Claim 16, delete “notches” and insert -- notches, --, therefor.

In Column 22, Line 17, in Claim 19, delete “engine;” and insert -- engine, --, therefor.

In Column 22, Line 21, in Claim 20, delete “control” and insert -- controller --, therefor.